

## EXECUTIVE SUMMARY

### ABSTRACT

During July 1988, the U.S. Geological Survey began a Remedial Investigation (RI) of contamination at Operable Unit 4 (OU 4). The objectives of the RI were to: (1) characterize the extent of contamination, (2) determine the fate of contaminants, and (3) develop a baseline risk assessment for the potential exposure pathways through soil, ground water and air. James M. Montgomery, Consulting Engineers, Inc. (JMM) began risk assessment studies in June 1989 working under a contract with Hill AFB.

The landfills at OU 4 are located along the top of a steep, terraced, north-facing escarpment that separates the Weber Delta from the Weber River valley. Landfill 1 covers about 5 acres and is located in the northeastern part of Hill AFB and landfill 2 covers about 4 acres and is located about 900 feet northwest of landfill 1.

Suspected dump sites, referred to collectively as the north gate dump sites, are located along Foulois Drive southeast of the north gate and along the Hill AFB boundary northeast of Foulois Drive. There is no documentation of dumping at these sites but it has been alleged that drums containing solvents and other material were disposed during unauthorized dumping episodes at various sites along Perimeter Road (Radian Corp., 1990, p. 1-4).

Hill AFB overlies three aquifers. Two of the aquifers, the Sunset and the Delta, are productive sources of good quality water and are used by both Hill AFB and surrounding communities. Water in these aquifers generally is confined and occurs at depths of 300 and 600 ft below the landfills. Shallow ground water, in which contamination has been detected, overlies the Sunset and Delta aquifers. Based on the ground-water classification criteria of the State of Utah and the chemical quality of ground water from uncontaminated wells in the shallow aquifer of OU 4, the ground water would be classified as "Drinking Water Quality", Class II (written commun., State of Utah, Dept. of Environmental Quality, August 21, 1991).

During 1986-90, 13 volatile organic and 2 inorganic contaminants were detected in the shallow ground water from monitoring wells and seeps in the area of OU 4. Trichloroethylene (TCE) was detected most frequently and in the highest concentrations.

TCE exceeded the primary maximum contaminant level (MCL) in water from 20 monitoring wells and 3 seeps; benzene exceeded the MCL in 1 well; and 1,2-DCA, nitrate, and sulfate were detected but did not exceed the MCLs in water from any of the wells or seeps. No semivolatile compounds, chlorinated herbicides, or petroleum hydrocarbons were detected in the samples. Twenty-six trace elements were analyzed in water samples from four wells, and boron, nickel, selenium, iron, and manganese were the only trace elements detected.

The southwesternmost (upgradient) occurrence of TCE noted during soil-gas surveys or in chemical analyses of water samples is immediately south of Foullois Drive at the north gate dump sites. The largest concentration of TCE outside the boundary extends north from the north gate dump site near well LF1GS6. A narrow tongue of the plume containing between 1,000 and 5,000  $\mu\text{g/L}$  extends about 1,000 ft from well LF1GS6, downgradient to South Weber Drive.

Inside the boundary of Hill AFB, the maximum concentration of TCE in ground water was about 11,000  $\mu\text{g/L}$ , and outside the boundary the maximum was 2,800  $\mu\text{g/L}$ . Inside the boundary of Hill AFB the contaminated area is about 17 acres, and outside the boundary, it is about 40 acres.

About 82 percent of the TCE in the water fraction of the subsurface is present in water exceeding 1,000  $\mu\text{g/L}$ , and this represents about 27 percent of the total volume of contaminated water. The total weight of the TCE in the contaminated water is about 990 lbs, or about 80 gallons of pure TCE product. If equilibrium conditions exist, then 170 gallons of TCE are sorbed to the contaminated soil fraction of the subsurface, for a total amount of TCE in the subsurface of 250 gallons.

No exposure pathways exist that currently (October 1990) present any significant health risks to people living or working in the vicinity of OU 4, and there is little potential for ecological harm to result from the contaminants present at OU 4. Human health risks associated with the occurrence of TCE, however, could develop in the future. TCE concentrations in the shallow ground water are quite high near the source areas at Hill AFB as well as near the Cutler residence, and could present a potential health risk should someone use this water for general domestic purposes such as drinking and showering.

#### INTRODUCTION

The U.S. Air Force (USAF), in performing its primary mission of defense of the United States, has frequently engaged in operations that deal with toxic and hazardous materials. The Department of Defense (DOD) has implemented the Installation Restoration Program (IRP) to identify the locations and contents of past toxic and hazardous material disposal and spill sites, and to eliminate the hazards to public health in an environmentally responsible manner. The IRP is the basis for response actions on USAF installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendment and Restoration Act (SARA) of 1986. Under the IRP, contamination resulting from past waste disposal is now being investigated at Hill AFB. The location of OU 4, one of the sites under the IRP and the subject of this report, is shown in figure ES-1.

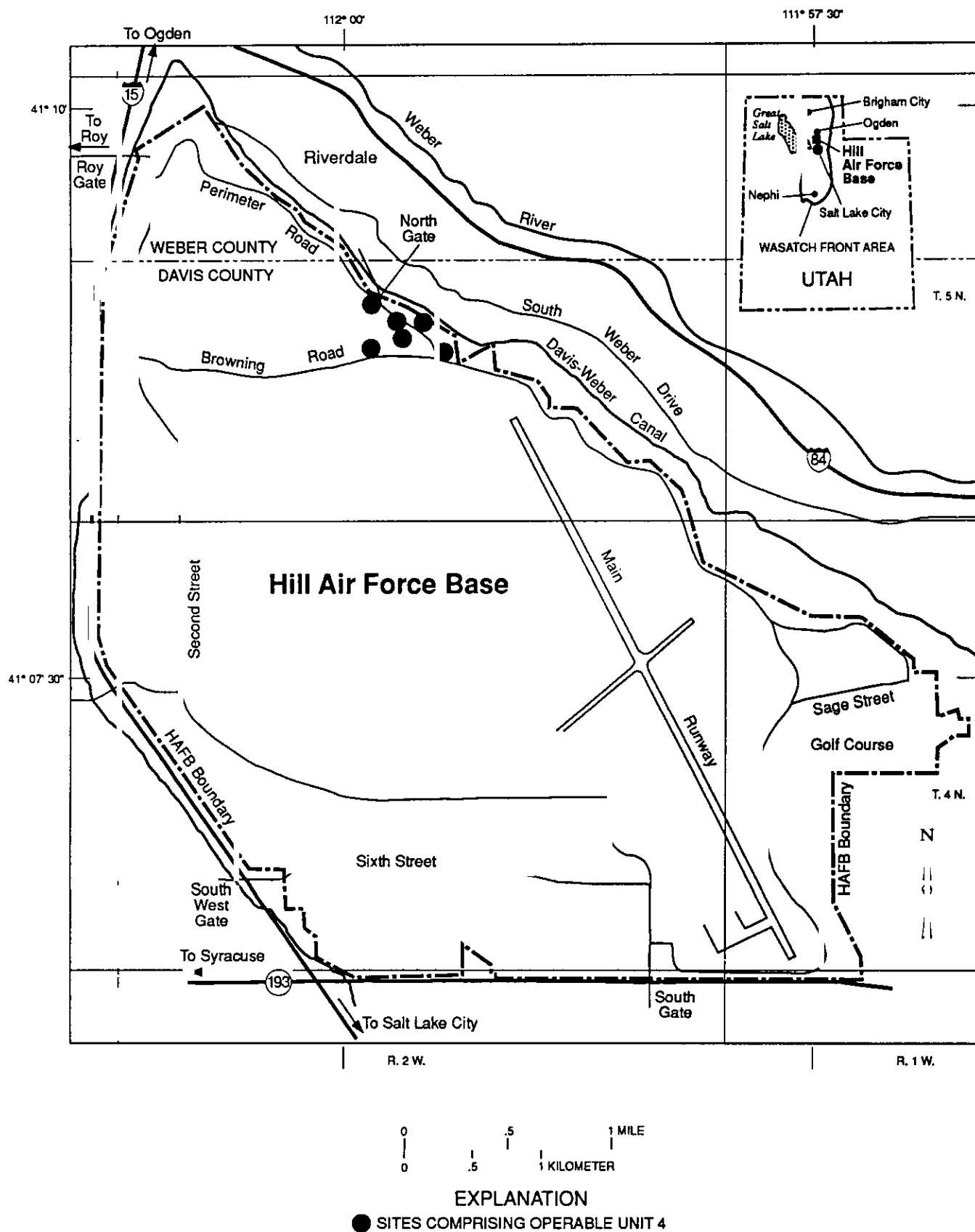


Figure ES-1.--Location of Operable Unit 4 on Hill AFB. (Modified from Radian Corporation, 1988, figure 1.6-1.).

## PURPOSE AND SCOPE OF THE INVESTIGATION

A Preliminary Assessment, formerly known as Phase I, the Records Search, was conducted by Engineering Science during 1981 (Engineering Science, 1982). This study provided a history of landfill operations at Hill AFB, and indicated that organic chemicals had not been disposed in landfills 1 and 2, which make up part of the area that was later consolidated and identified as OU 4.

A Site Inspection, formerly known as Phase II, the Confirmation/Quantification Stage, was conducted by Radian Corp. from November 1985 to November 1987 (Radian Corp., 1988). Two monitoring wells were constructed downgradient from landfills 1 and 2, and one monitoring well was constructed upgradient from the landfills in the shallow aquifer. Laboratory chemical analyses were performed on water samples collected from the wells, and TCE was detected in both of the downgradient wells, but was not detected in the upgradient well. The concentration of TCE in water from the well downgradient of landfill 1 was 4,185  $\mu\text{g/L}$ , while the concentration in water from the well downgradient of landfill 2 was 6.08  $\mu\text{g/L}$ . The primary maximum contaminant level for TCE in drinking water is 5.0  $\mu\text{g/L}$ . The detection of TCE indicated that further investigation was necessary.

In September 1987, the U.S. Geological Survey began an investigation at OU 4. The primary objectives were to complete the scoping activities and characterize the site. Scoping activities completed were: (1) collection of existing data about the site, (2) preliminary identification of site boundaries, (3) identification of potential Applicable or Relevant and Appropriate Requirements (ARARs), and (4) preparation of the Work Plan, Quality-Assurance Plan, and Health and Safety Plan.

During July 1988, the U.S. Geological Survey began an RI of contamination at OU 4. The objectives of the RI were to: (1) characterize the extent of contamination, (2) determine the fate of contaminants, and (3) develop a baseline risk assessment for the potential exposure pathways through soil, ground water and air.

Site-characterization activities completed as part of the RI were: (1) definition of the landfill boundaries, (2) determination of vertical and horizontal hydraulic gradients, (3) determination of physical and hydrologic characteristics of soils and sedimentary units, (4) determination of extent of contamination, (5) determination of potential contaminant source areas, (6) determination of contaminant concentrations, and (7) identification of unidentified compounds reported in previous reports (Radian Corp., 1988, p. 4-244).

JMM began risk assessment studies in June 1989 working under a contract with Hill AFB. Using data gathered during the site characterization, JMM estimated current and future health risks posed by OU 4.

## ENVIRONMENTAL SETTING AND SITE DESCRIPTION

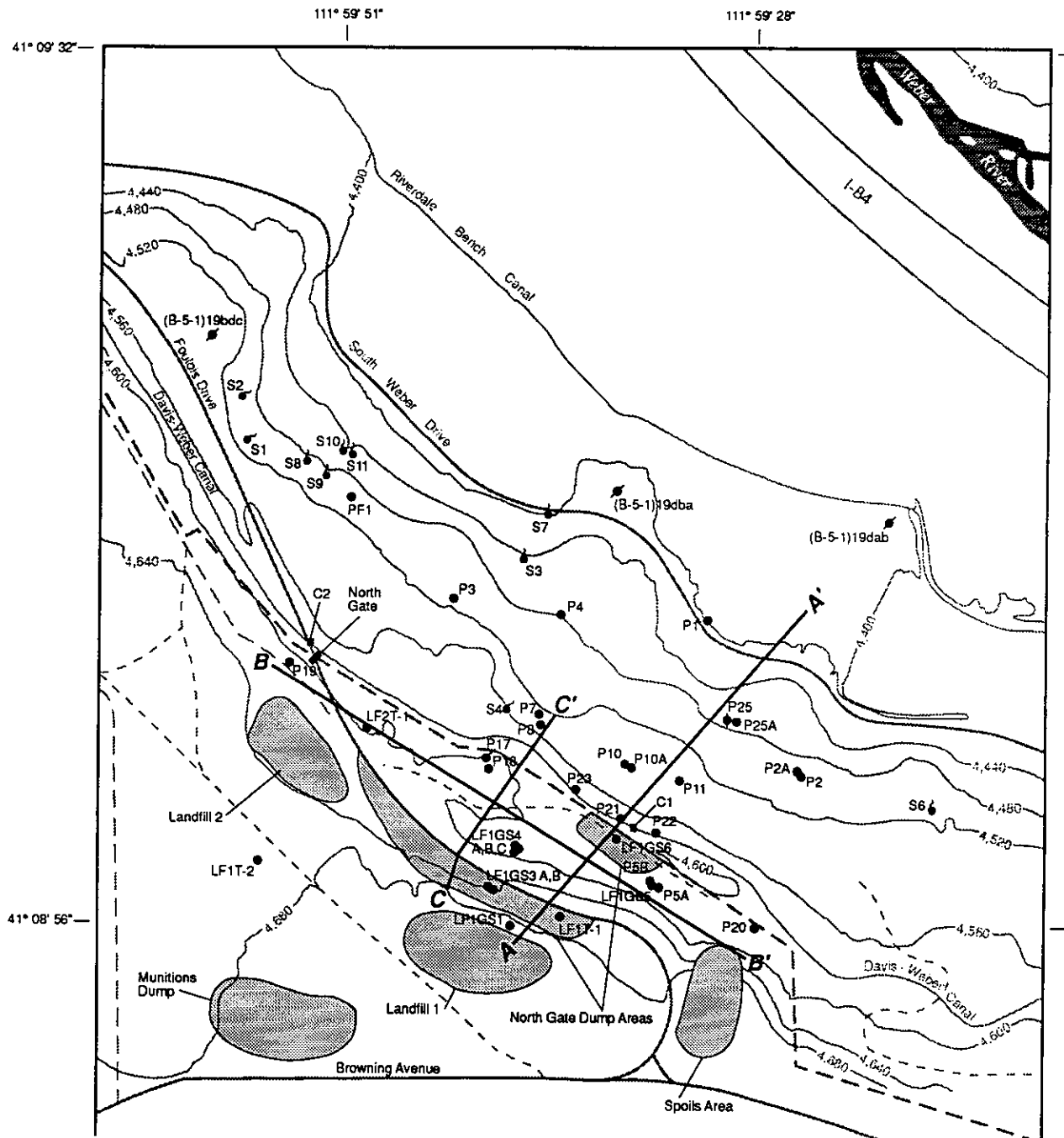
Hill AFB is located in northern Utah about 25 mi north of Salt Lake City and about 5 mi south of Ogden (fig. ES-1). Hill AFB covers about 6,700 acres and is located on the Weber Delta, a terrace about 300 ft above the valley floor in Weber and Davis Counties.

The landfills at OU 4 are located along the top of a steep, terraced, north-facing escarpment that separates the Weber Delta from the Weber River valley (fig. ES-2). The Weber Delta consists of unconsolidated clay, silt, sand, and gravel.

Landfill 1 covers about 5 acres and is located in the northeastern part of Hill AFB. Mr. Joseph Fisher, former foreman of refuse collection, recalled the landfill was about 25 ft deep. Available records indicate few, if any, chemicals were disposed in the landfill. Landfill 1 may have received waste from the Ogden Arsenal, which could have included waste oils and solvents from their vehicle-maintenance facility (Radian Corp, 1988, p. 1-23).

Landfill 2 covers about 4 acres and is located about 900 ft northwest of landfill 1. Landfill 2 was operated between 1963 and 1965; general waste was dumped down the side of the hill and periodically burned. There are no records of chemicals being disposed at this site.





### EXPLANATION

- A A' SECTION LINES**
- HILL AIR FORCE BASE BOUNDARY
- IMPROVED DIRT ROADS
- SECONDARY DIRT ROADS
- P17  
(B-5-1)19dba  
S4  
◆ P25  
■ C2
- MONITORING WELL AND NUMBER
- PRIVATE OR PUBLIC WELL AND NUMBER
- SEEP AND NUMBER
- TEST HOLE AND NUMBER
- CANAL SAMPLING SITE AND NUMBER

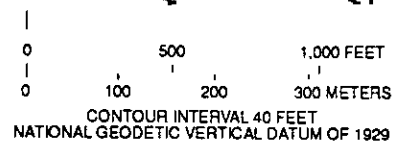


Figure ES-2.--Location of data-collection sites and sections near Operable Unit 4.

The spoils area is located about 700 to 1,000 ft east of landfill 1 and at the east corner of the intersection of Browning Avenue and Foullois Drive. The spoils area has operated since 1972. Only solid waste is known to have been dumped at the site but the potential exists that some of the materials may have been contaminated with fuels from minor spills (Ed Heyse, oral commun., March 1991).

Suspected dump sites, referred to collectively as the north gate dump sites, are located along Foullois Drive southeast of the north gate and along the Hill AFB boundary northeast of Foullois Drive. There is no documentation of dumping at these sites but it has been alleged that drums containing solvents and other material were disposed during unauthorized dumping episodes at various sites along Perimeter Road (Radian Corp., 1990, p. 1-4). Perimeter Road intersects Foullois Drive near the north gate.

The munitions dump was located about 400 ft southwest of landfill 1 and was operated by the Ogden Arsenal as an above-ground storage area for munitions during World War II. Spent shell casings were observed in the area during the site classification activities at OU 4.

## FIELD PROGRAM

The U.S. Geological Survey conducted seven major field activities at Hill AFB as part of the RI at OU 4. These activities included: (1) an electromagnetic (EM) geophysical survey, (2) a borehole geophysical survey, (3) soil-gas surveys, (4) installation of 29 monitoring wells, (5) collection and analysis of soil and ground-water samples, (6) aquifer tests and (7) regular measurement of water levels in monitoring wells. The field activities began in February 1988 and ended in May 1990.

## SUMMARY OF RESULTS

Hill AFB overlies three aquifers (fig. ES-3). Two of the aquifers, the Sunset and the Delta, are productive sources of good quality water and are used by both Hill AFB and surrounding communities. Water in these aquifers generally is confined and occurs at depths of 300 and 600 ft below the landfills. Shallow ground water, in which contamination has been detected, overlies the Sunset and Delta aquifers.

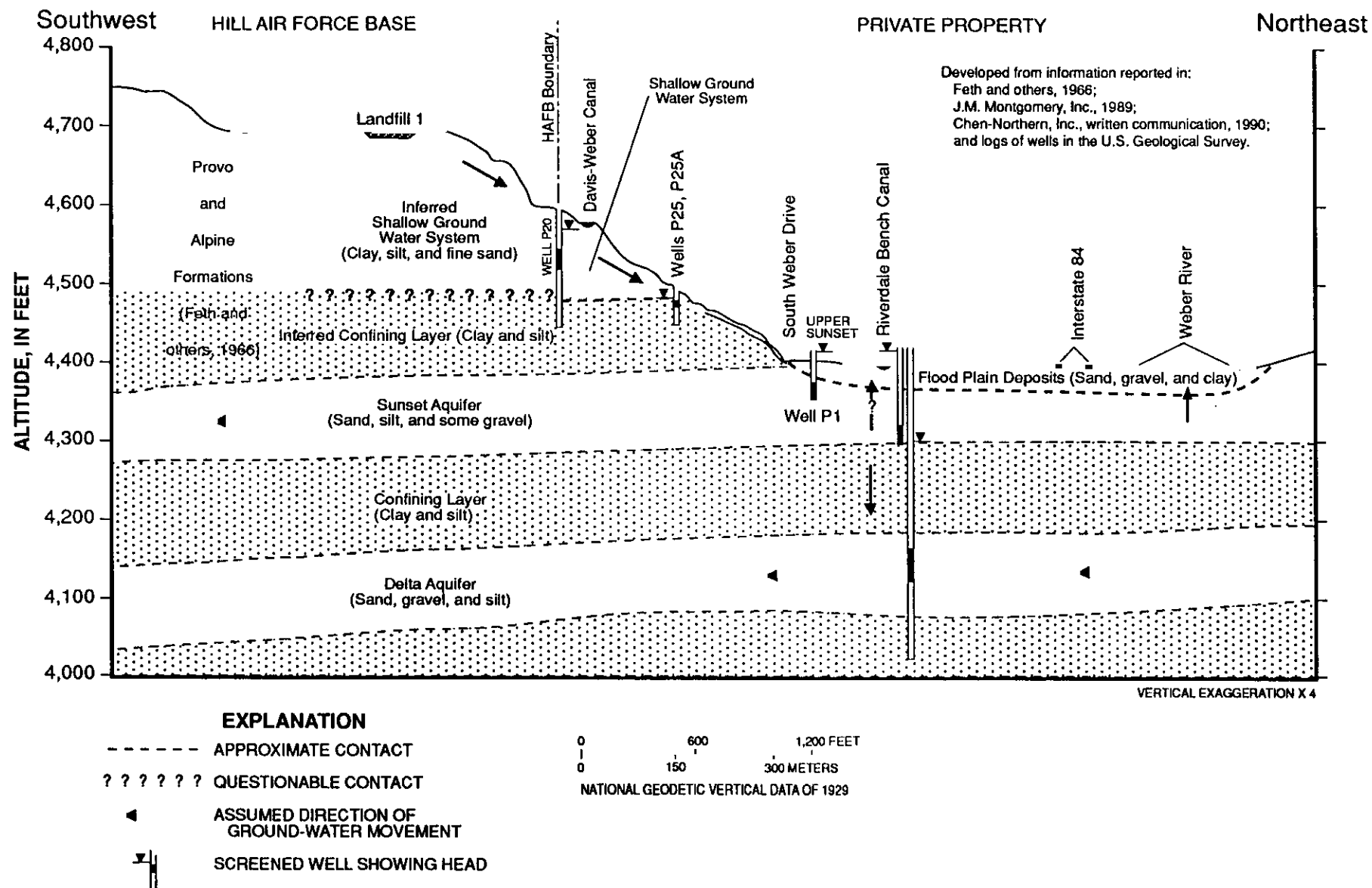


Figure ES-3.--Diagrammatic section of the probable relation between the shallow ground-water system in the area of Operable Unit 4, the flood-plain deposits of the Weber River, and the underlying regional confined aquifers.

Drilling in the vicinity of OU 4 into the Provo and Alpine Formations has shown that the lithologic character of the deposits is mainly clay with lesser quantities of silt and very fine sand (fig. ES-3). The lithologic character varies laterally and with depth, although not substantially in the first 60 ft.

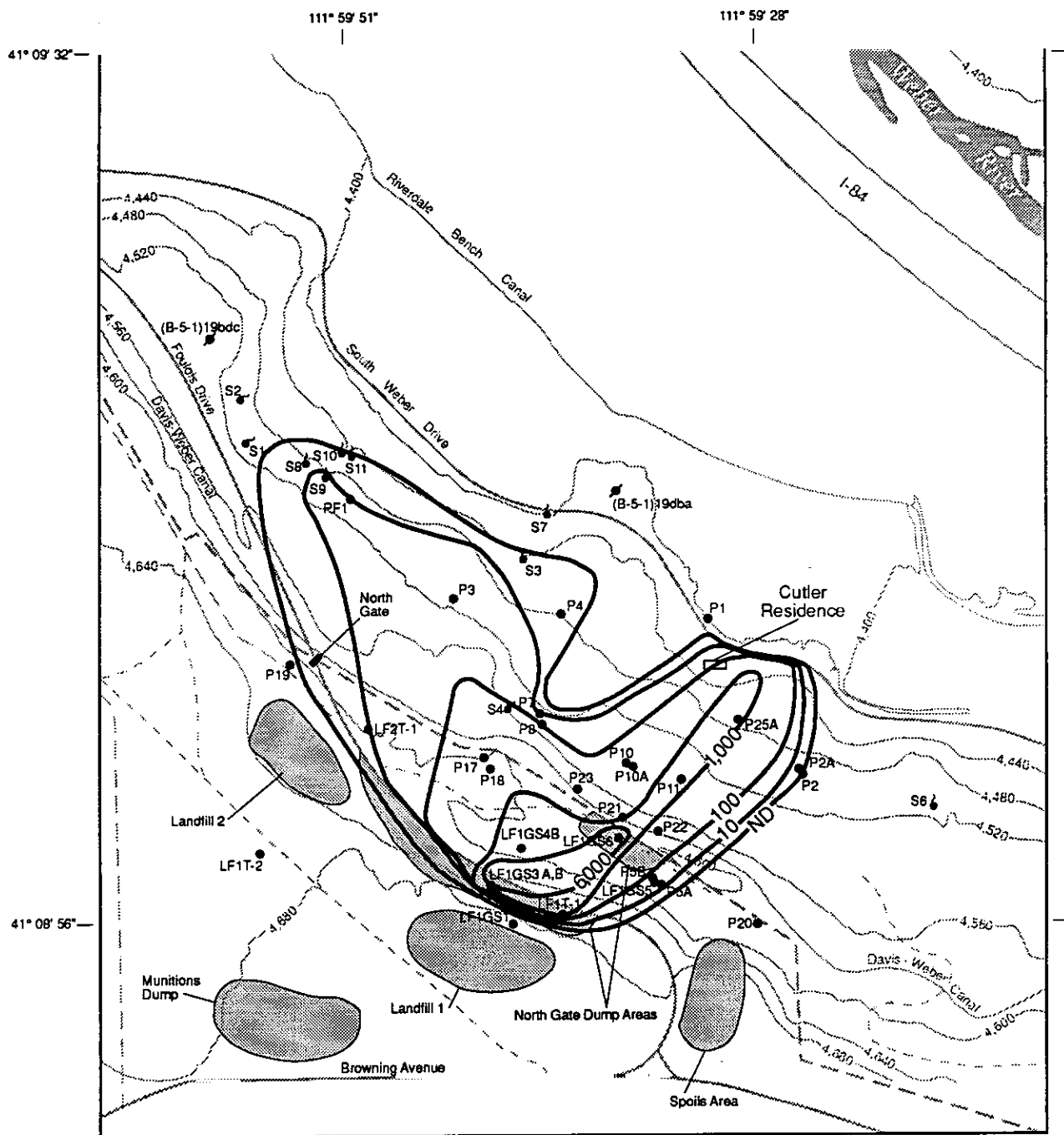
The sediments comprising the shallow ground-water system are about 200 ft thick beneath the landfills and have been thinned, presumably by erosion, northeast of OU 4 near the hillsides immediately above South Weber Drive and the flood-plain deposits (fig. 4.4-1). Most ground-water movement near the landfills occurs in interfingering layers of sands and silts in the upper 30 to 60 ft of sediments. The upper part of the sediments, which includes sandy and silty material, is less than 20 ft thick along the hillsides.

Discharge from the shallow ground-water system occurs primarily as seeps along the steep escarpments below the canal and at the base of the hillside. Some of this ground water probably subsequently infiltrates into the Weber River flood-plain deposits. Some ground water may flow in the subsurface from the sediments comprising the confining layer underlying the shallow ground-water system directly into the flood-plain deposits. Water from the shallow ground-water system subsequently mixes with water that has moved upward from the Sunset aquifer in the flood-plain deposits. Downward vertical percolation through the thick sediments along the hillside is limited by the horizontal layering and small vertical hydraulic-conductivity values.

During 1986-90, 13 volatile organic and 2 inorganic contaminants were detected in water from monitoring wells and seeps in the area of OU 4. TCE was detected most frequently and in the highest concentrations. Currently (October 1990), the Federal Safe Drinking Water Act (SDWA) has primary MCLs that will apply as ARARs for three of the volatile organic contaminants, TCE, benzene, and 1,2-DCA, and one inorganic contaminant, nitrate. Since SDWA has no primary MCL for sulfate, the Utah primary MCL would apply as an ARAR. Comparison of the concentrations of observed contaminants to appropriate standards indicates that TCE exceeded the primary MCL in water from 20 monitoring wells and 3 seeps; benzene exceeded the MCL in 1 well; and 1,2-DCA, nitrate, and sulfate did not exceed the MCLs in water from any of the wells or seeps.

Water from all wells was analyzed for volatile organic compounds (VOCs), and at least once for inorganic parameters, and water from wells LF1GS3B, LF1GS6, and LF1T-1 was analyzed for semivolatile organic compounds. Water from wells LF1GS6 and LF1T-1 was analyzed for chlorinated herbicides and gross alpha and beta. Water from wells LF1T-1 and LF2T-1 was analyzed for total petroleum hydrocarbons, and water from wells LF1T-1, LF2T-1, LF1GS3B, and LF1GS6 was analyzed for heavy metals. Although water samples were collected from only a few wells and analyzed for compounds other than VOCs, water from three of the wells yielded the largest concentrations of TCE found in the area of OU 4 and were believed to be near the source areas where the contaminants were disposed. No semivolatile compounds, chlorinated herbicides, or petroleum hydrocarbons were detected in the samples. Gross alpha and beta levels were believed to be consistent with average background conditions. Twenty-six trace elements were analyzed in water from four wells, and boron, nickel, selenium, iron, and manganese were the only trace elements detected.

The southwesternmost (upgradient) occurrence of TCE noted during soil-gas surveys or in chemical analyses of water samples is immediately south of Foulis Drive at the north gate dump sites (fig. ES-4). Wells LF1T-1 and LF1GS3B, located along Foulis Drive about 300 ft apart, are believed to be in or near the most upgradient source area. The source of the contaminants observed in this area may be from roadside disposal and/or leakage from barrel storage. The largest concentration of TCE detected, 11,000 µg/L, was in water from well LF1GS6. It is not known if well LF1GS6 is in a separate disposal area or if the contaminants have migrated from the area near the upgradient well LF1T-1 down to well LF1GS6. It is possible that both wells are in or near separate disposal areas.



### EXPLANATION

- 100— LINE OF TRICHLOROETHYLENE (TCE) CONCENTRATION, 1986-90--Concentrations in micrograms per liter. Interval is variable. "ND", not detected. Primary maximum contaminant level for TCE is 5 micrograms per liter
- HILL AIR FORCE BASE BOUNDARY
- IMPROVED DIRT ROADS
- SECONDARY DIRT ROADS
- PF1 ● MONITORING WELL AND NUMBER
- (B-5-1)19dba ● PRIVATE OR PUBLIC WELL AND NUMBER
- S4 ● SEEP AND NUMBER

0 500 1,000 FEET  
0 100 200 300 METERS  
CONTOUR INTERVAL 40 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure ES-4.--Maximum concentrations of trichloroethylene in shallow ground water near Operable Unit 4.



Long term trends in the concentration may indicate that the plume is migrating past the site. Wells LF1GS3B, LF1GS4B, LF1GS6, LF1T-1, and LF2T-1 had sufficient analyses to describe trends of TCE concentrations since sampling began in 1986 (fig. ES-5). Of particular significance is the decreasing trend in the most upgradient well, LF1T-1, whereas the concentration in some of the wells farther downgradient are increasing. This suggests that the more concentrated part of the plume is moving from the most upgradient wells to the downgradient wells.

The largest concentration of TCE outside the boundary extends north from the north gate dump site near well LF1GS6. A narrow tongue of the plume containing between 1,000 and 5,000  $\mu\text{g/L}$  extends about 1,000 ft from well LF1GS6, downgradient to South Weber Drive. During March 1990, well LF1GS6 contained 11,000  $\mu\text{g/L}$  and well P25A, about 250 ft upgradient from South Weber Drive, contained 1,300  $\mu\text{g/L}$ .

Hydraulic-head and chemical data from clusters of wells at four sites were used to construct an approximate flow path for contaminant migration from well LF1GS3B to the discharge area along the downgradient side of the canal bank (fig. ES-6). Along this approximate flow path, TCE is flushed from the unsaturated zone and upper few feet of the saturated zone near well LF1GS3B, migrates downgradient from well LF1GS3B into the saturated zones of wells LF1GS4B, LF1GS4C, and P18, and discharges along the downgradient side of the canal bank at seep S4. Some ground water is lost by evapotranspiration along the bank and TCE does not reach the cluster of wells, P7 and P8.

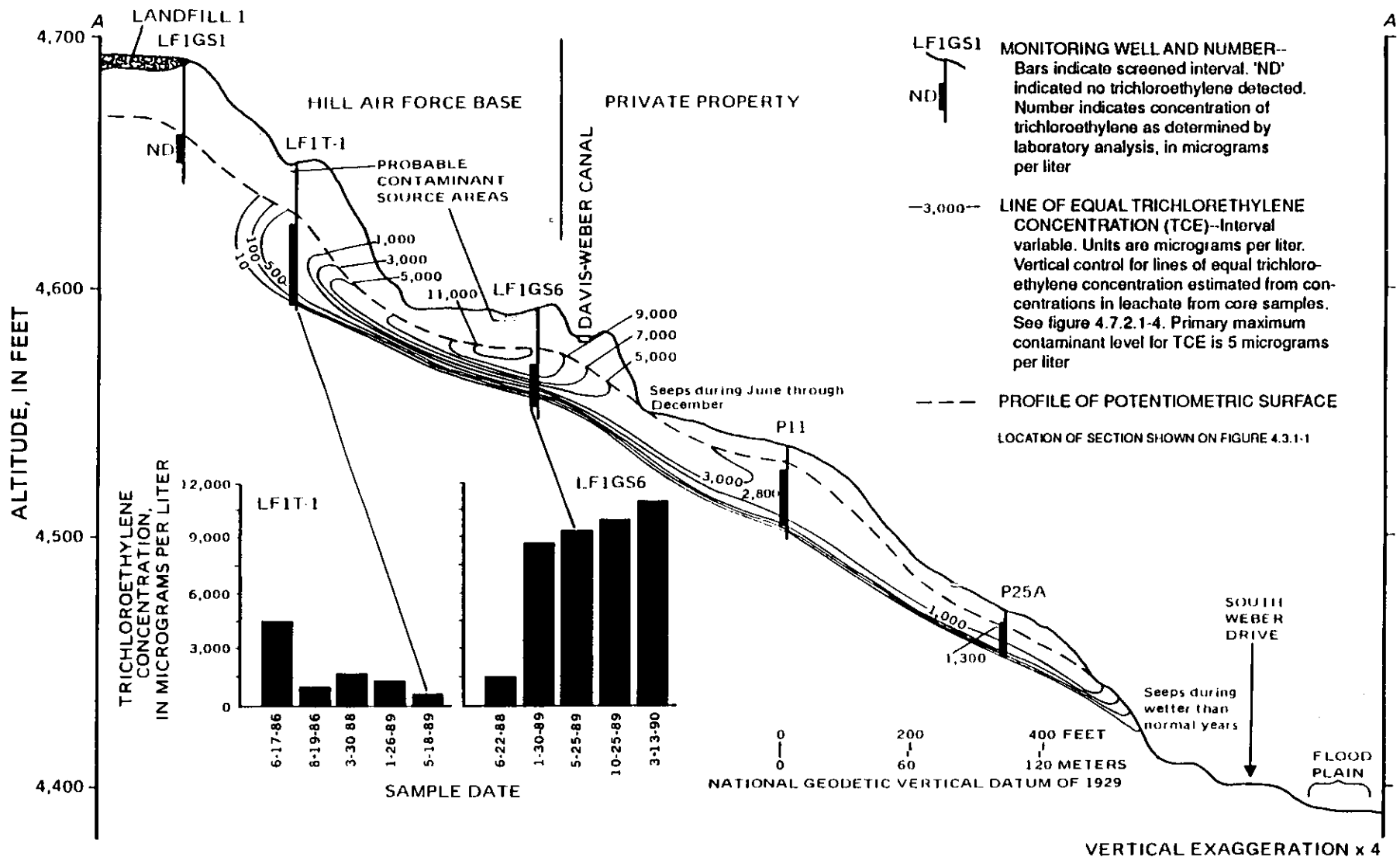


Figure ES-5--Vertical, lateral, and temporal variations of trichloroethylene concentrations in ground water along section A-A', 1986-90, in the area of Operable Unit 4.

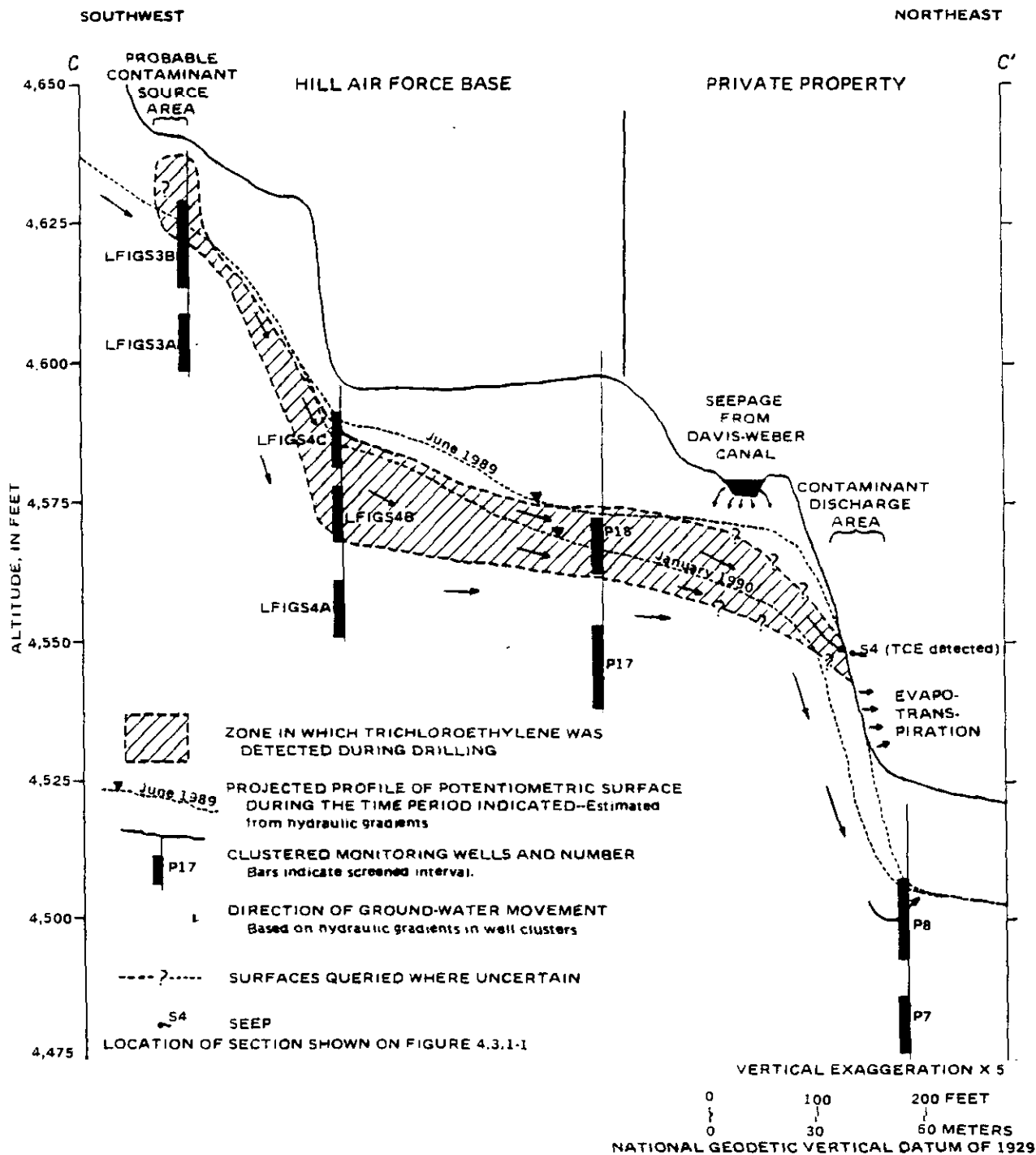


Figure ES-6.--Approximate movement of trichloroethylene along section C-C' from probable contaminant source to discharge location in the area of Operable Unit 4.

Inside the boundary of Hill AFB, the maximum concentration of TCE in ground water was about 11,000  $\mu\text{g/L}$ , and outside the boundary the maximum was 2,800  $\mu\text{g/L}$  (blind duplicate sample contained 3,100  $\mu\text{g/L}$ ). Inside the boundary of Hill AFB the contaminated area is about 17 acres, and outside the boundary, it is about 40 acres (fig. ES-4).

About 82 percent of the TCE in the water fraction of the subsurface is present in water exceeding 1,000  $\mu\text{g/L}$ , and this represents about 27 percent of the total volume of contaminated water. The total weight of the TCE in the contaminated water is about 990 lbs, or about 80 gallons of pure TCE product. If equilibrium conditions exist, then 170 gallons of TCE are sorbed to the contaminated soil fraction of the subsurface, for a total amount of TCE in the subsurface of 250 gallons.

No exposure pathways exist that currently (October 1990) present any significant health risks to people living or working in the vicinity of OU 4, and there is little potential for ecological harm to result from the contaminants present at OU 4. Human health risks associated with the occurrence of TCE, however, could develop in the future. TCE concentrations in the shallow ground water are quite high near the source areas at Hill AFB as well as near the Cutler residence, and could present a potential health risk should someone use this water for general domestic purposes such as drinking and showering. Some of the shallow ground water is used for irrigation but currently (October 1990) none is being used for domestic purposes. Thus, the risk assessment scenarios presented for domestic use are hypothetical situations that could occur if the water is used in the future.

Surface water near OU 4 consists of water diverted from the Weber River into the Davis-Weber Canal and ground water discharging as seeps between the canal and South Weber Drive. No contaminants have been detected in the Davis-Weber Canal, however, VOCs including TCE have been detected in water from some of the seeps. Environmental receptors have the greatest potential to be exposed through this media, including wild and domestic animals, and crops. However, due to the fact that VOCs volatilize when exposed to air and because they are readily metabolized by animals, this potential exposure route is unlikely to be significant.

The probability of an individual getting cancer by using water from the shallow ground-water system in the most contaminated area near well LF1GS6, drinking water and taking a daily shower for a period of 30 years, was estimated to be equal to 7 in 1,000 (a cancer risk of  $7 \times 10^{-3}$ ). This is greater than the  $10^{-4}$  to  $10^{-6}$  range that comprises the minimum level of risk that EPA considers to be significant. Near well P25A, a cancer risk was estimated to equal  $1 \times 10^{-3}$ . The hazard index for the most contaminated area near well LF1GS6 was estimated to equal 50, which is also significant, as hazard indices greater than 1 indicate that noncancerous health effects may be a significant possibility. This hazard index is even more significant since inhalation exposure was not included in the calculation due to the lack of a reference dose for TCE. A hazard index equal to 6 was estimated for the area near well P25A.

The shallow ground-water system essentially terminates, primarily due to erosion, above the clay layer along the hillside southwest of the Weber River flood plain. Water from the shallow ground-water system reaches the flood-plain deposits either by discharging as seeps at the base of the hillside and then infiltrating into the flood-plain deposits, or as ground-water inflow through the predominately clay layers just beneath the shallow ground-water system. This water then mixes with, and probably is diluted by, water in the flood-plain deposits (some of which probably has moved upward from the upper part of the Sunset aquifer). The markedly different inorganic-chemical compositions of water from the shallow ground-water system and from the flood-plain deposits indicates that the two systems are either isolated or significant dilution is occurring. In either case, there is apparently little potential for the Weber River to be affected by contaminants from OU 4.

There are currently no significant exposures resulting from TCE in air. It is unlikely that this situation will change in the future with regard to inhaling outdoor air; however, TCE was detected during a soil-gas survey conducted in the immediate vicinity of the Cutler residence, although the concentrations of TCE were very close to the detection limits. If the plume of contamination has migrated beneath the Cutler basement, there would be a potential for TCE vapors to migrate into the basement and create a risk. The presence of the high TCE concentrations in ground water 100 ft upgradient of the house, the presence of a small hole in the basement floor, and the fact that people probably spend a few hours per day in this basement are a strong indication that this pathway could pose a health risk in the future.

#### RECOMMENDATIONS

The need for better areal coverage for specific types of chemical data for soils and water will require additional field investigation at OU 4. An addendum workplan describing plans to complete the field investigation was prepared by the U.S. Geological Survey (Kidd M. Waddell, written commun., February 24, 1992).

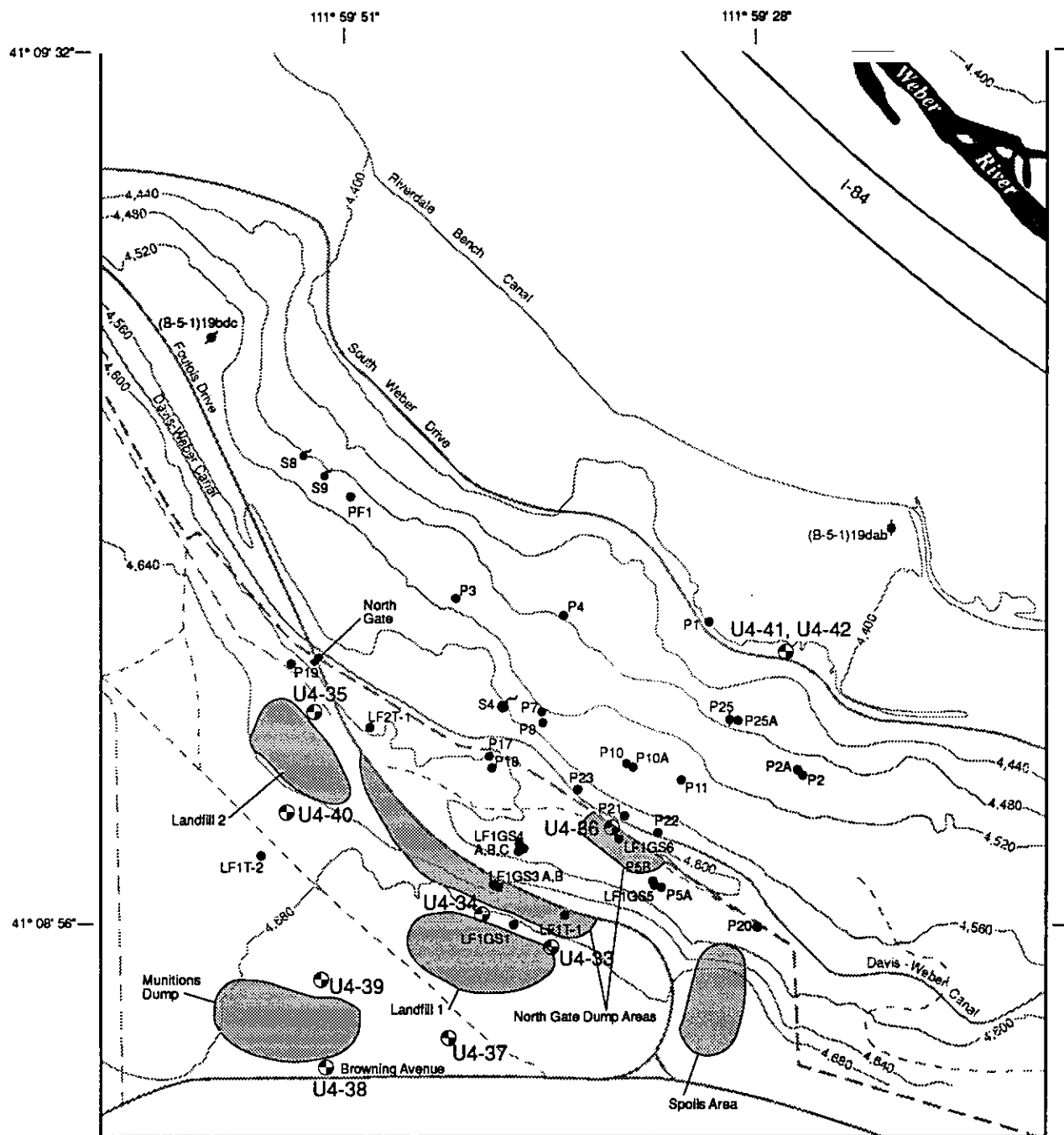
Uncertainty exists in identification of the source area(s) of the contaminants found downgradient of the landfills. For example, the absence of contaminants at well LF1GS1 is the only direct evidence that TCE and possibly other contaminants do not originate in landfill 1.

To determine whether landfills 1 or 2, and/or the munitions dump are sources of contaminants, upgradient and downgradient wells are needed. Figure ES-7 shows the locations of proposed wells U4-33, U4-34, U4-35, U4-37, U4-38, U4-39, and U4-40 and the schedules for analysis of sediment (drill cores) and ground water are shown in columns A and B of table ES-1.

The TCE in the unsaturated zone needs to be quantified in areas where it has been identified by soil-gas surveys in the north gate dump sites (fig. ES-8). Also, additional chemical analyses are needed to identify other potential contaminants in suspected source areas, including the north gate dump sites, landfills 1 and 2, and the munitions dump. The locations of proposed soil-boring sites in the north gate dump areas and the surface sampling sites for the munitions dump and landfills 1 and 2 are shown in figure ES-8 and the analytical schedules for analysis of the soil borings are shown in column C and D of table ES-1.

The vertical extent of contamination near well LF1GS6 needs to be defined. Well LF1GS6 (fig. ES-7) was drilled to a depth of 38.3 ft and the zone of contamination was not fully penetrated. Because the water from this well is the most contaminated of all wells on OU 4, and the greatest concentrations of TCE were observed in soil gas in the unsaturated zone, the area around this well is a suspected source area. Well U4-36 (fig. ES-7) should be constructed within a few feet of well LF1GS6, and to a depth sufficient to penetrate the zone of contamination, which is estimated be about 50 to 90 ft below land surface. The schedule for analysis of the sediments (from drill cores) and ground water from well U4-36 are shown in column E, table ES-1.





- EXPLANATION**
- HILL AIR FORCE BASE BOUNDARY
  - IMPROVED DIRT ROADS
  - SECONDARY DIRT ROADS
  - P17 ● MONITORING WELL AND NUMBER
  - ⊙ U4-40 PROPOSED MONITORING WELL AND NUMBER
  - (B-5-1)19dba PRIVATE OR PUBLIC WELL AND NUMBER
  - ◆ P25 TEST HOLE AND NUMBER
  - S9 ● SEEP AND NUMBER

0 500 1,000 FEET  
0 100 200 300 METERS  
CONTOUR INTERVAL 40 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure ES-7.--Location of existing wells and selected seeps and proposed monitoring wells for Operable Unit 4, Hill AFB.

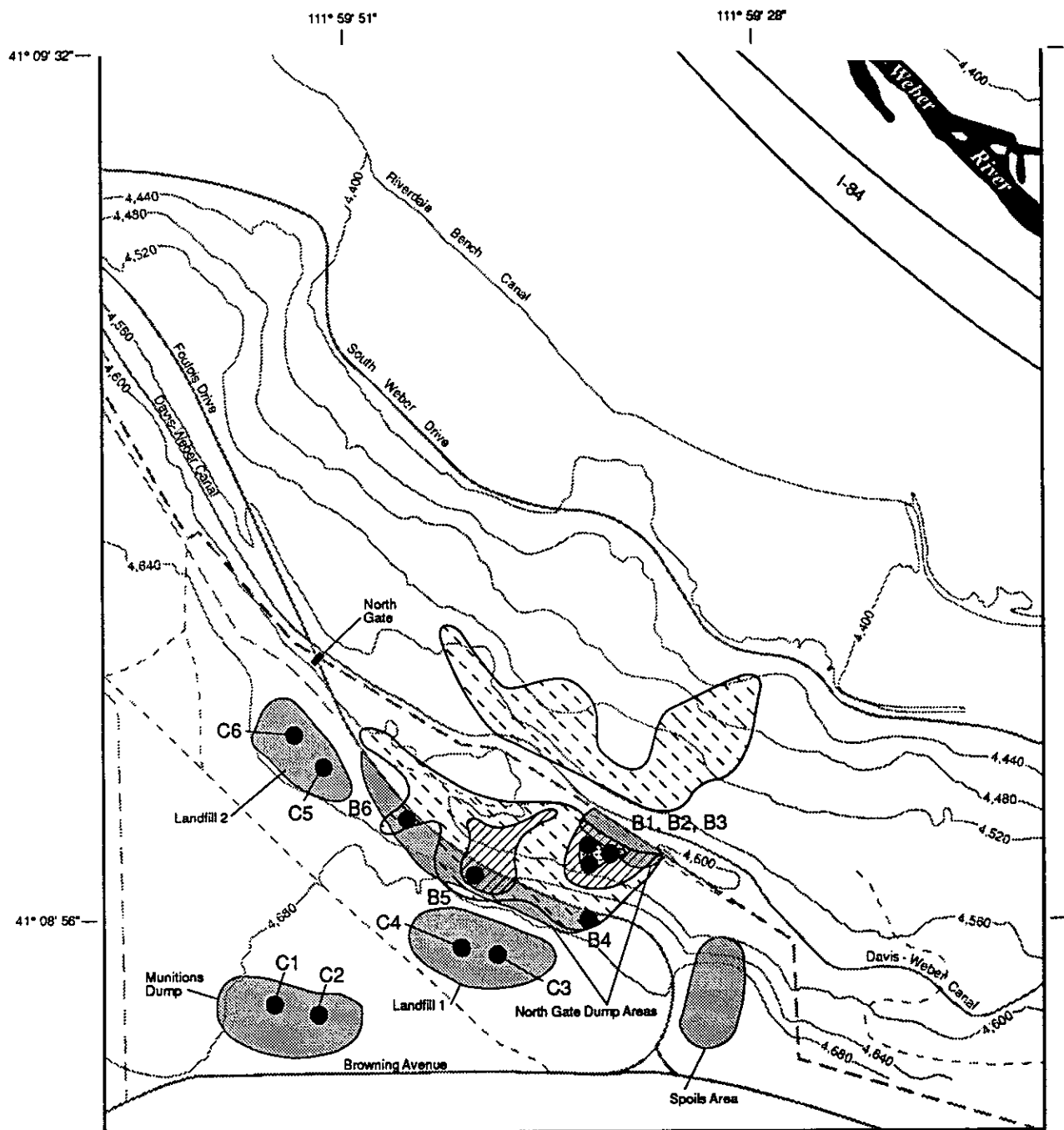
Table ES-1 Summary of chemical analyses and schedules for  
~~analytical~~ sampling activities at Operable Unit 4, Hill AFB  
 (See figures ES-8 and ES-9 for locations of proposed sampling sites)  
 [ —, no sample will be collected]

Parameter	Analytical method <sup>1</sup>	A Wells U4-37, U4-38, and U4-40	B Wells U4-33, U4-34, U4-35 and U4-39	C Soil borings B1, B2, B3, B4, B5, and B6	D Soil borings C1, C2, C3, C4, C5, and C6	E Wells U4-36 and U4-41	F Seeps S4 and S9	Total <sup>1</sup>
<b>WATER SAMPLES</b>								
Volatile Organics	ES24	3	4	—	—	2	—	9
Semivolatile Organics	ES25	3	4	—	—	2	—	9
Chlorinated Herbicides	ES15	3	4	—	—	2	—	9
Metals (ICP scan)	SW6010	3	4	—	—	2	2	11
Arsenic	SW7060	3	4	—	—	2	2	11
Mercury	SW7470	3	4	—	—	2	2	11
Lead	SW7421	3	4	—	—	2	2	11
Cyanide	335.2 CL	3	4	—	—	2	2	11
Common Anions (Includes chloride, fluoride, sulfate, nitrate, and orthophosphate)	A429	3	4	—	—	2	2	11
Alkalinity	A403	3	4	—	—	2	2	11
<b>Sediment Samples</b>								
Purgeable Volatile Organics	SW8240	—	8	30	6	—	2	44
TCLP		—	—	12	—	—	—	12
Semivolatile Organics	SW8270	—	8	30	6	—	—	44
Chlorinated Herbicides	SW8150	—	8	30	6	—	—	44
Organochlorine Pesticides & PCBs	SW8080	—	8	30	6	—	—	44
Metals (ICP scan)	SW3050/SW6010	9	8	30	6	—	—	53
Arsenic	SW3050/SW7060	9	8	30	6	—	—	53
Mercury	SW7470	9	8	30	6	—	—	53
Lead	SW7421	9	8	30	6	—	—	53
Cyanide	335.2 CLPM	9	8	30	6	—	—	53

<sup>1</sup> Analytical Method References

SW Methods	Test Methods for Evaluating Solid Waste, Laboratory Manual: Physical/Chemical Methods, SW-846, 3rd ed. (U.S. Environmental Protection Agency, 1986).
E Method	Methods for Chemical Analysis of Water and Wastes, EPA Manual 600/4-79-020 (U.S. Environmental Protection Agency, 1983).
A Method	Standard Methods for the Examination of Water and Wastewater, 16th ed. (American Public Health Association, 1985).
CLPM	Contract Laboratory Program, Modified.
TCLP	Toxicity Characteristics Leaching Procedure (U.S. Environmental Protection Agency, 1990, Pub. 9234.2-08/FS, May 1990).

<sup>1</sup> Total number of samples do not include samples for quality assurance.  
 ES-26



### EXPLANATION

ORGANIC VAPOR CONCENTRATION, AS TRICHLORO-ETHYLENE, IN PARTS PER MILLION - Concentrations determined in field using a gas chromatograph



0.1 - 1.0

1.0 - 10

MORE THAN 10

--- HILL AIR FORCE BASE BOUNDARY

--- IMPROVED DIRT ROADS

--- SECONDARY DIRT ROADS

B5 ● PROPOSED SOIL BORING SITES

C2 ● PROPOSED SURFACE SOIL SAMPLING SITES

0 500 1,000 FEET  
0 100 200 300 METERS  
CONTOUR INTERVAL 40 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure ES-8.--Location of the proposed soil boring and surface sampling sites for Operable Unit 4, Hill AFB.

Additional wells are needed to verify that no contamination has moved into the flood plain immediately downgradient of the leading edge of the contaminant plume and to better define the horizontal and vertical components of the ground-water gradient in the flood plain. A two-well cluster (wells U4-41 and U4-42, fig. ES-8) should be constructed immediately north of South Weber Drive in the flood plain deposits and along a line projected from monitoring well P11 to well P25A.

If contamination is found in well U4-41, another well then would be needed about 1,000 ft northeast of well U4-41. The additional well, in conjunction with well P1 and well U4-41, would provide water-level data which could be used to approximate the potentiometric surface and directions of ground-water movement in the flood plain.

Additional chemical analyses are needed for the water and surface-soils associated with seeps containing TCE. TCE was detected in 3 seeps downgradient from Hill AFB (S4, S8, and S9, fig. ES-7) but only a limited suite of chemical analyses have been performed on the water and no analysis of the surface soil around the seeps has been made.

A more extensive analytical schedule is recommended for seeps S4 and S9, which is indicated in column F of table ES-1. Seep S8 is in the same general discharge area as S9 and would not have to be sampled. If contaminants are found in the source areas upgradient of seeps S4 and S9, and the contaminants are not included in the analytical schedule for the seeps, the schedule for the seeps should be revised accordingly.

A plume of ground water containing relatively high concentrations of dissolved solids has been defined for OU 4. Water samples should be collected twice a year from the 18 existing wells listed in table ES-2, and analyzed according to the schedules shown in table ES-3, so that spatial and temporal changes in the inorganic and organic chemistry of the ground water can be monitored. If additional contaminants are detected from the analyses of water from any of the new wells or sediment samples the monitoring program should be revised accordingly. Water levels should also be measured four times a year in each of the wells selected for the semiannual monitoring program in order to monitor changes in the potentiometric surfaces and vertical hydraulic gradients.

Because it would be beneficial to the remediation process to quantify the amount of mixing that is occurring between contaminated water associated with a potential leachate plume and uncontaminated water in the shallow ground-water system, water samples should also be collected for geochemical analyses. In addition, these analyses would help in final definition of contaminant source areas, which is necessary before remediation begins.

Table ES-2 Wells recommended for continued monitoring of water quality at semiannual intervals and water levels at quarterly intervals, in the area of Operable Unit 4.

Well number
LF1T-1
LF2T-1
LF1GS1
LF1GS3A
LF1GS3B
LF1GS4A
LF1GS4B
LF1GS6
P1
P3
P4
P5A
P5B
P11
P17
P18
P25A
(B-5-1)19bdc

**Table ES-3 Chemical parameters, analytical methods, and number and type of analyses for semi-annual monitoring wells at Operable Unit 4, Hill AFB.**

[ --, no sample will be collected]

Parameter	Analytical method <sup>1</sup>	Number of well samples	Number of blind duplicates	Number of trip blanks	Total
<b>Water Samples</b>					
Purgeable Volatile Organics	SW8240	18	2	2	22
Common Anions	A429	18	2	--	20
Alkalinity	A403				
Nitrite	E353.2	18	2	--	20
Metals	SW6010	18	2	--	20

<sup>1</sup> Analytical Method References

SW Methods	Test Methods for Evaluating Solid Waste, Laboratory Manual: Physical/Chemical Methods, SW-846, 3rd ed. (U.S. Environmental Protection Agency, 1986).
A Method	Standard Methods for the Examination of Water and Wastewater, 16th ed. (American Public Health Association, 1985).
E Method	Methods for Chemical Analysis of Water and Wastes, EPA Manual 600/4-79-020 (U.S. Environmental Protection Agency, 1983).

The similarities between the shape and location of the TCE and sulfate plumes, as defined by elevated concentrations of these constituents in ground water from wells at OU 4, may be an indication that these contaminants have a common origin. Analysis of water samples for naturally occurring stable-isotope ratios, including sulfur, hydrogen, oxygen, carbon, and nitrogen, should help to identify the source of contaminants and quantify the amount of mixing if the two contaminants have different sources. Stable-isotope ratios for sulfur and carbon would be very different from naturally occurring ratios if the source of inorganic contamination is from chemical reactions in the landfills; whereas the stable-isotope ratios for oxygen and hydrogen would be useful in determining the source of water and to more definitely trace flow paths for both sulfate and TCE contaminants.

Water samples should be collected from selected wells to provide preliminary stable-isotope-ratio data that could be compared to determine if ratios identified in areas with different possible sources of solutes are distinct. If sufficient variability exists between the areas and a range of stable-isotope ratios is established, then mixing ratios can be calculated and a more detailed geochemical investigation that would include stable-isotope-ratio analyses of water from all the wells should be conducted.